Common LROC-NAC DEM Artifacts

Examples from DEMs created by the LMMP Team

This document serves to display examples of common digital elevation model (DEM or DTM) errors or artifacts. The process of DEM extraction by comparing the paired stereo images is never perfect and the resulting DEMs will contain some level of inaccuracies (Kirk, 2008). The random height errors are most obvious in DEMs extracted from low signal-to-noise imagery and tend to give the surface a faceted or exaggerated rough appearance (this is particularly apparent in the shaded reliefs). Localized areas of high noise may result from shadows or other low contrast features. Errors that have more identifiable patterns, unrelated to the image quality, are artifacts of the particular extraction or editing techniques. For example, sections of the DEM that are edited manually, though improved, may still be distinguishable by their smooth texture from the more accurately portrayed natural terrain in other areas (manual edits can also be clearly identified in the confidence maps). Linear artifacts along which the DEM height changes discontinuously by a small amount may also originate from multiple sources in the data processing. For example, such small offsets are commonly seen at the join between data from the two cameras of the LROC-NAC system.

To maintain the maximum scientific integrity of the data and to preserve detail in other areas, no attempt has been made to smooth over these artifacts.

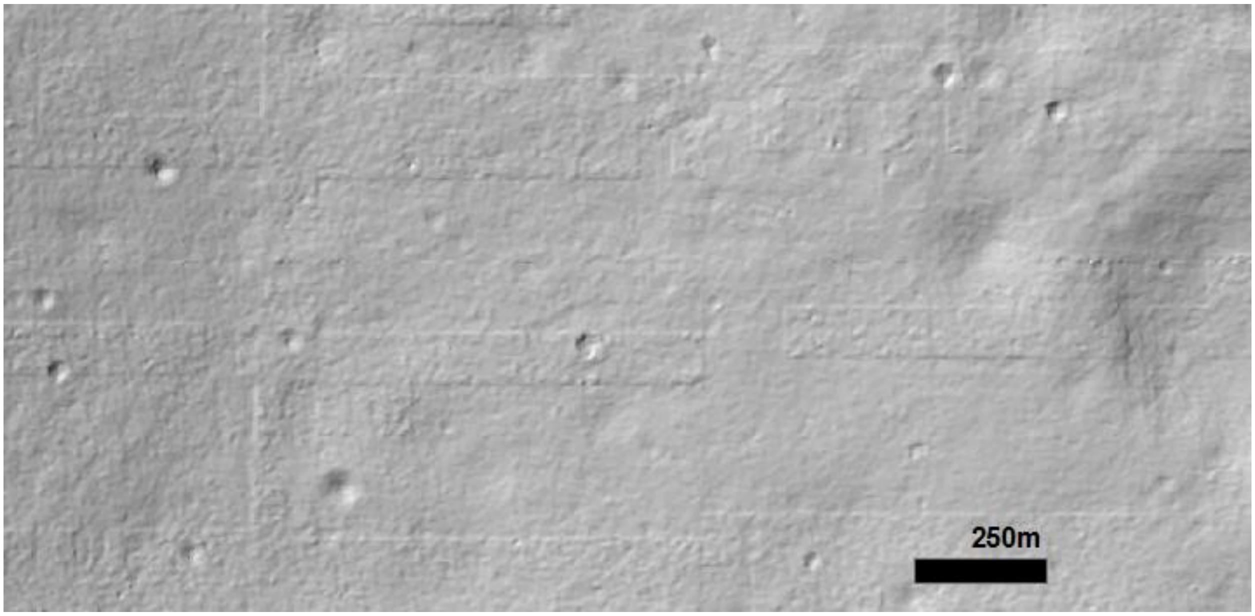

Figure 1. The rectangular artifacts shown above can be traced to the SOCET SET Next-Generation Automatic Terrain Extraction (NGATE) matching algorithm, which divides the whole DEM into small blocks. For each block, NGATE computes a set of transformation parameters between ground XYZ and image line, sample, and X parallax. The set of parameters are computed based on the sensor model as well as the specific location. As a result, there may be some minor blocking effect (horizontal line and/or vertical line along the block boundaries). Elevation changes across both inter-camera seams and block boundaries should always be less than the expected vertical precision of 1 m. This image is from the ASU South Pole – Aitken basin hillshade (LRO_NAC_Shade_51S171E_2mp.tif).

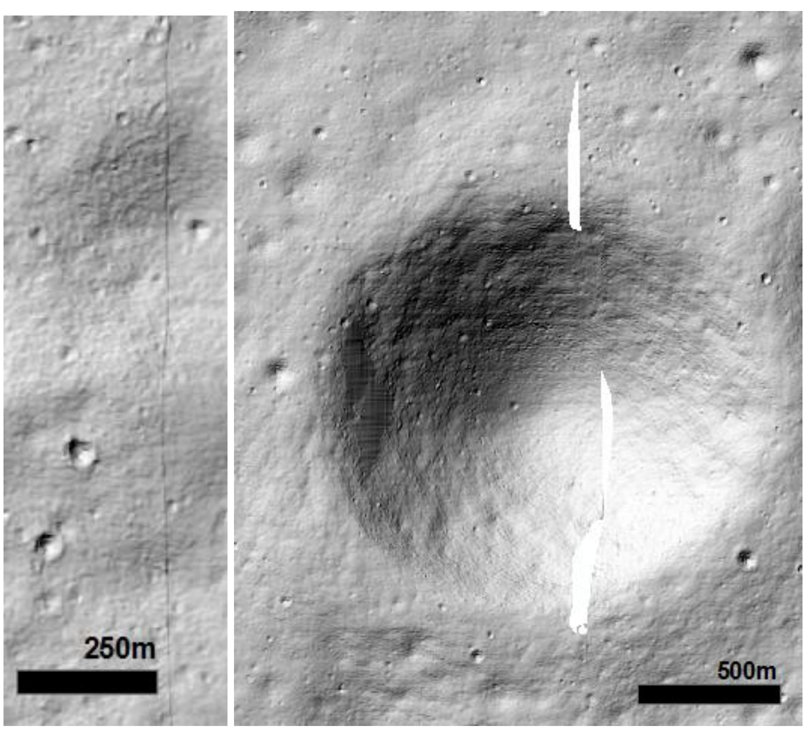

Figure 2. These two images display typical vertical artifacts showing the join between data from the two cameras of the LROC-NAC system. The right side shows an extreme case where the seam is actually large enough to cause a gap in the data. Both images shown here are from the USGS Balmer Basin hillshade.

(LRO_NAC_Shade_19S070E_150cmp.tif).

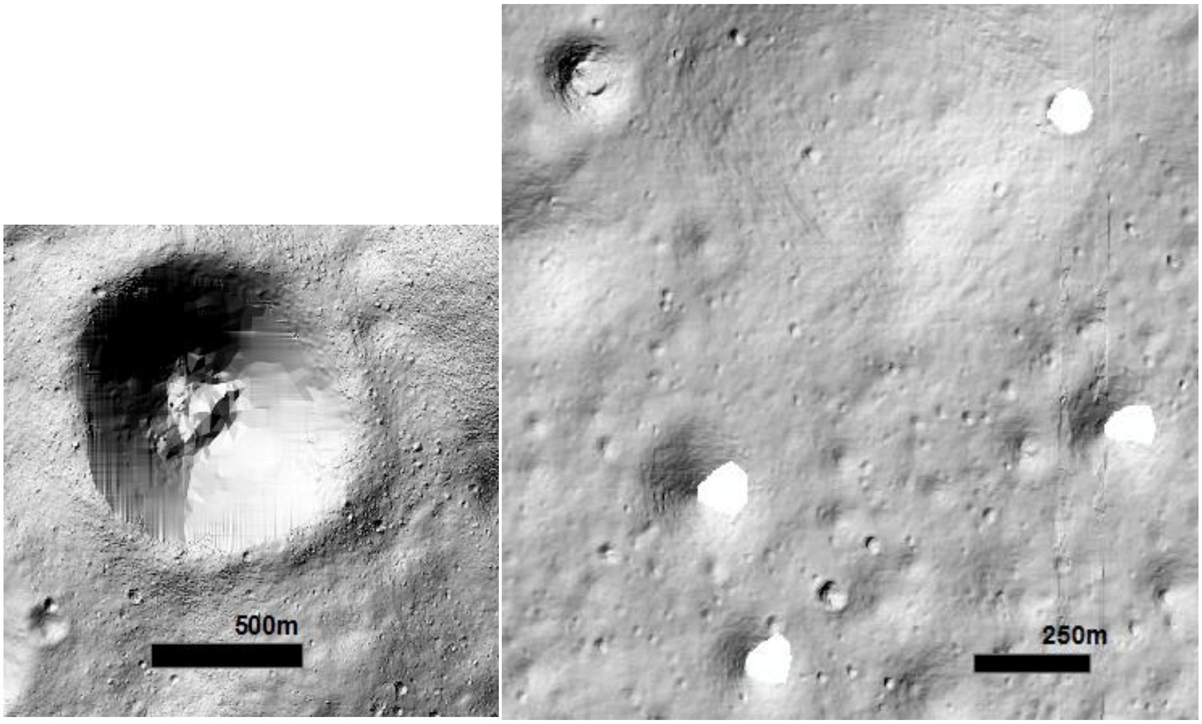

Figure 3. Irregular patterns within craters or areas of large slopes are generally from shadows. Many of these shadows have been edited which can result in odd patterns (left). In some cases these areas are set to NoData within the DEM (right). This left image is from the USGS Apollo 16 hillshade (LRO_NAC_Shade_09S015E_150cmp.tif) and the right image is from the USGS Balmer Basin hillshade (LRO_NAC_Shade_19S070E_150cmp.tif).

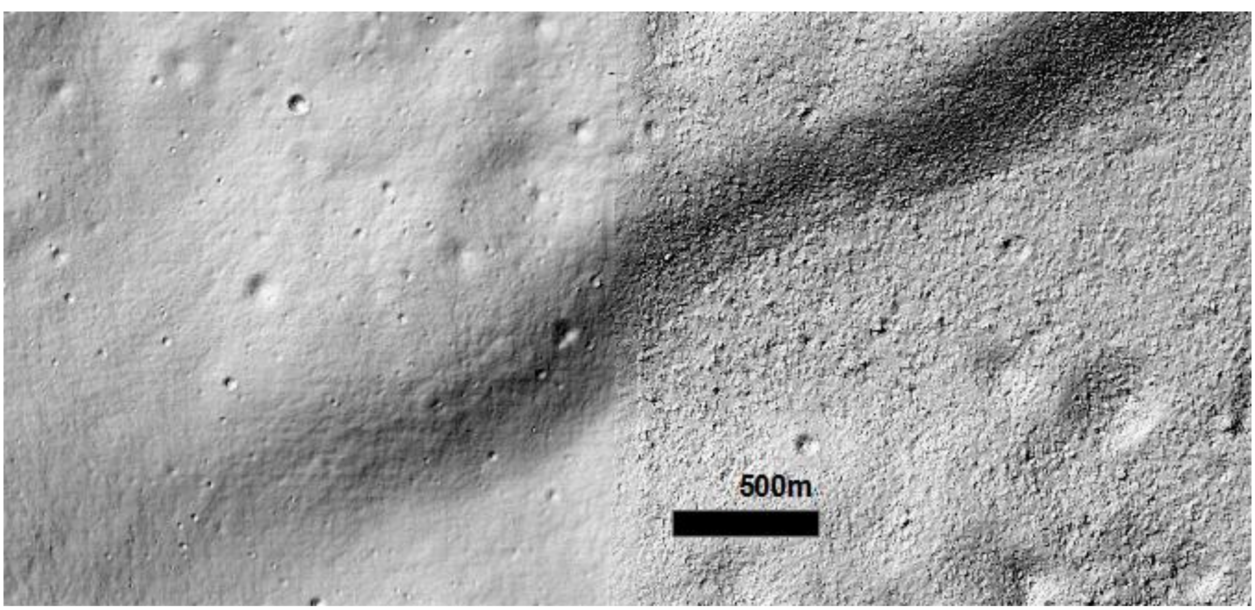

Figure 4. This image shows a join between two stereo-pairs. It also shows how neighboring stereo-pairs with different signal-to-noise ratios can result in different apparent roughness. Here the right-side displays a faceted or exaggerated rough appearance. The image shown is from the USGS Riccioli Crater hillshade (LRO_NAC_Shade_03S286E_150cmp.tif).

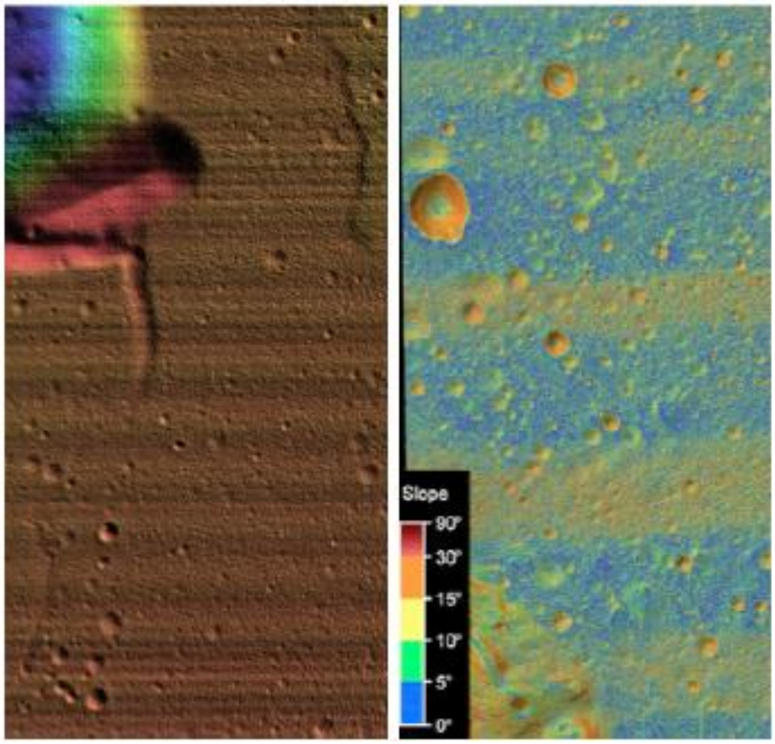

Figure 5. From (Mattson 2011), these two images display jitter artifacts from spacecraft motion while in orbit. A significant number of stereo images acquired in the LRO Commissioning Phase had a level of jitter that caused this distinctive ripple pattern of 10s of meters in elevation in the DEMs (left). A LRO Science Phase slope map (right) shows noisy bands, but no ripples, from jitter. Note that the bands are not elevation changes. Jitter effects are always most apparent in flat topography (McEwen 2010).

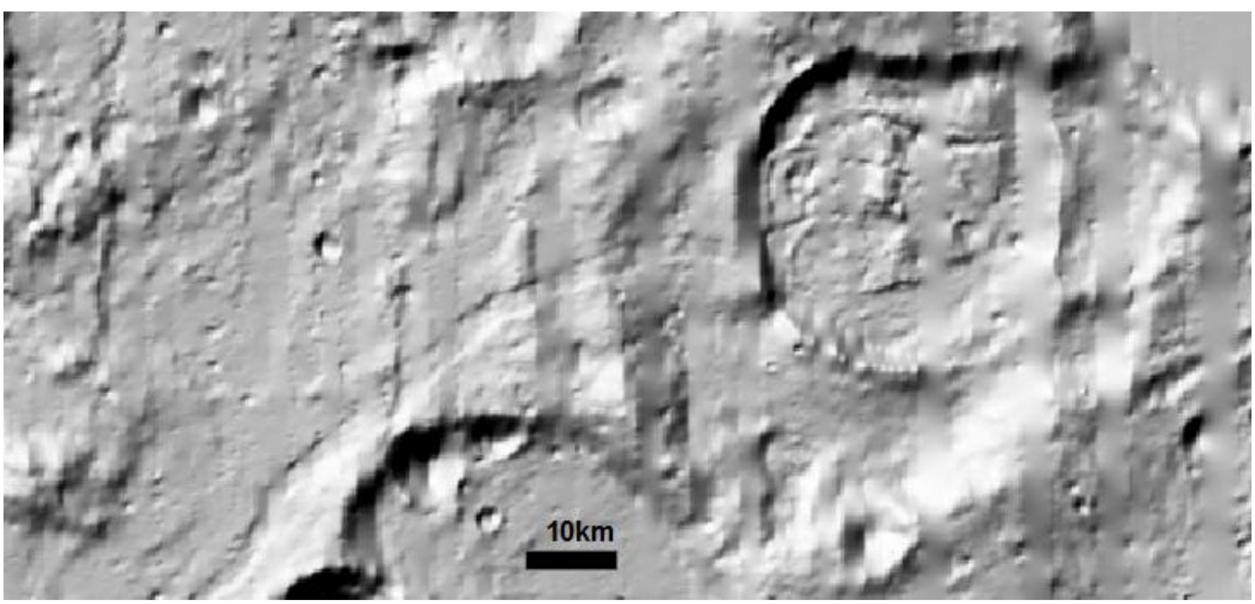

Figure 6. What is shown above are actually are not artifacts from stereo processing but interpolation artifacts from the LOLA point to DEM conversion. The areas above that are smooth are data gaps in the original data. The data gaps are simply filled in by using a spline tension interpolation method over the original point data (Smith 2008).

References:

Kirk, R.L., and 18 colleagues, 2008. Ultrahigh resolution topographic mapping of Mars with MRO HiRISE stereo images: Meter-scale slopes of candidate Phoenix landing sites. J. Geophys. Res., 113, E00A24. doi:10.1029/2007JE003000.

Mattson, S. S., et al., 2011, Continuing Analysis of Spacecraft Jitter in LROC-NAC, 42nd Lunar and Planetary Science Conference, abs. # 2756, URL: http://www.lpi.usra.edu/meetings/lpsc2011/pdf/2756.pdf

McEwen A. et al., 2010, The High Resolution Imaging Science Experiment (HiRISE) during MRO's Primary Science Phase (PSP), Icarus, doi:10.1016/j.icarus.2009.04.023, URL: http://www.lpl.arizona.edu/~shane/publications/mcewen_etal_icarus_2010.pdf

Smith, David E. et. al., 2008, The Lunar Orbiter Laser Altimeter Investigation on the Lunar, Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, URL: http://lunar.gsfc.nasa.gov/lola/images/smith_lola_ssr09.pdf